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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b> <b>H01Q 1/36</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 97/18601</b> <b>(43) International Publication Date:</b> 22 May 1997 (22.05.97)
<b>(21) International Application Number:</b> PCT/SE96/01483 <b>(22) International Filing Date:</b> 15 November 1996 (15.11.96)  <b>(30) Priority Data:</b> 9504071-3                      15 November 1995 (15.11.95)      SE 08/590,951                    24 January 1996 (24.01.96)        US  <b>(71) Applicant (for all designated States except US):</b> ALLGON AB [SE/SE]; P.O. Box 500, S-184 25 Åkersberga (SE).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> ÖSTERWALL, Torsten [SE/SE]; Fredrikslundsvägen 43, S-161 44 Bromma (SE).  <b>(74) Agents:</b> MODIN, Jan et al.; Axel Ehmers Patentbyrå AB, P.O. Box 10316, S-100 55 Stockholm (SE).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.          Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> DUAL BAND ANTENNA MEANS  <div data-bbox="267 1113 1380 1354" data-label="Image"> </div> <b>(57) Abstract</b> <p>An antenna means enabling operation of a portable radio communication device within two separated frequency bands, for example, at 900 MHz and 1800 MHz. The antenna means comprises a feed portion coupled to circuitry of the portable radio communication device, first and second helical elements wound on a common core, coaxially and longitudinally coextending. The coils are galvanically separated except possibly at one end, they each have one free end and at least one of the coils is coupled directly to circuits of the portable radio communication device.</p>		

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**DUAL BAND ANTENNA MEANS****BACKGROUND OF THE INVENTION**5     Technical field of the invention

The invention relates generally to a multi-band antenna means having at least two radiating elements coupled, via a feed portion, to circuitry of a radio communication device, wherein  
10     the antenna means is capable of performing transmission and reception within each one of at least two, separated frequency bands. Specifically, it relates to a dual band antenna device for a hand-portable telephone, which is capable of both transmitting and receiving on two separated frequency bands.

15

Description of Related Art

In the past antenna means including helical elements have been used for hand-portable cellular telephones in order to achieve  
20     compact dimensions and durability. One feature of a resonant antenna in general is that it is operable within one fundamental frequency band and within higher frequency bands, but only those having a fixed and predetermined relation to the fundamental frequency band. One problem related to small-size  
25     helical antennas in general is their narrow bandwidth.

GB-A 2 206 243 discloses a helical antenna for operating at predetermined upper and lower frequencies having another ratio than that of the natural frequencies of the helical antenna,  
30     e.g., the ratio of 2:1 between center frequencies, in order to communicate in two different distress beacon systems. The helical antenna disclosed therein is directed toward solving the problem of providing a helical antenna device capable of operating at two different, selectable frequencies, thus  
35     overcoming the fact that a helical antenna is usually restricted to resonating at fixed frequencies being non-harmonically related to the fundamental frequency of the helical antenna. The proposed solution involves providing a

straight conductor inside part of a helical winding and being connected to an upper end thereof. The lower end of the helical winding is connected to transceiver circuitry. By selecting the dimensions of the helical winding and the length and

5 construction of the straight conductor, the two different operating frequencies are to be selected. The disclosed antenna device is excited in different modes and it appears from the disclosed diagram (Fig 2B) as though the upper band is extremely narrow, which would make it difficult for the antenna  
10 to operate in a cellular telephone system. Moreover the construction of this antenna seems complicate manufacturing. In view of the problem to be solved in GB-A 2 206 243, it discloses the prior art closest to the invention.

15 US 4 442 438 discloses another helical antenna means with a conductive member extending through a helical structure in order to enable the antenna means to resonate at two different frequencies. The antenna means has a feed port from which the helical structure extends in opposite directions.

20 EP-A1 0 593 185 discloses a wideband antenna arrangement directed toward providing a coil antenna means which can be used instead of a whip antenna particularly in a digital cellular telephone system proposed for Japan, wherein the  
25 center frequencies of the transmission band and the reception band, respectively, are located around 933 MHz with a separation of 130 MHz, giving a ratio of about 1:1,16 between the center frequencies. The main problem to be solved in EP-A1 0 593 185 is to attain a wider operable frequency band than one  
30 single helix can provide alone, col. 1, lines 29-30, and lines 45-47. The proposed solution consists of two antenna coils tuned to include different frequencies. The two antenna coils are arranged on a common axis either in line, one inside the other, or interwound. The transmission and reception coils are  
35 interconnected at one end and are connected via a duplex filter to transmitter and receiver circuitry, respectively. Arranging two helical elements in close proximity is a very delicate task, and EP-A1 0 593 185 does not seem to provide sufficient

instructions on how to arrange and connect the helical elements in order to actually obtain a working antenna means having the desired wideband characteristics.

5 US 4 309 707 discloses further wideband antenna arrangements which aims at providing a compact antenna maintaining wideband characteristics, wherein one or several structures, each consisting of two coaxial and longitudinally coextensive  
10 helices joined together at one end and having opposite chirality, are arranged close to each other in a number of different configurations. This way the structures are coupled in order to provide wide overall bandwidth of the antenna arrangement. The different structures exhibit resonance center frequencies of, e.g., 24.5, 33.9, 43.4, and 51.5 MHz, a ratio  
15 of 1:1.19 - 1:1.38 between adjacent center frequencies of the structures. This disclosure is clearly directed toward achieving a continuous wide band.

US 4 772 895 discloses another wideband antenna arrangement  
20 wherein a first and a second helical element are arranged concentrically and partly overlapping. The first element is arranged inside the second element. One end of each element is free. The other ends of the first and second elements are coupled to a feed portion and a ground portion, respectively,  
25 of a coaxial conductor. In order for the first element and second elements to give together a sufficient wide band, e.g., 35 MHz, at, e.g., 155 MHz, the first element has a length of approximately three times that of the second element. This corresponds to resonance center frequencies of, e.g., 115 and  
30 356 MHz, for the first and second elements alone in free space, respectively. Apparently, the described results imply that the second element is connected to ground potential and not to the feed point of the first element.

35 AU 22 843 discloses various wideband antenna arrangements including helical elements. It teaches several general ways of achieving a continuous wide band using helices, provided that the difference in resonant frequencies of the helices is not

too large.

#### SUMMARY OF THE INVENTION

5 A main object of the invention is to provide a dual band antenna means capable of transmitting and receiving RF signals in each one of two different frequency bands. Specifically the antenna means is intended for a portable radio device capable of both transmitting and receiving in two separated frequency  
10 bands. This will allow the use of the inventive antenna means to provide operability of a hand-portable telephone in two or more telephone systems, for example, a combination of AMPS (824-894 MHz) and PCS (1850-1990 MHz), or GSM (890-960 MHz) and PCN (1710-1880 MHz), possible also combined with DECT (1880-  
15 1900 MHz). Another object of the invention is to provide a dual band antenna means which exhibits high efficiency, radiation lobe pattern without significant "dead angles", and sufficient wide band characteristics in each of its operable bands. Moreover, the antenna means of the invention should enable a  
20 suitable interface to the radio device, so that no switching means is required in order to operate within more than one frequency band. Yet another object of the invention is to provide a dual band antenna means compact and durable enough for portable radio equipment. Still another object of the  
25 invention is to provide a dual band antenna means which is suited for manufacturing in large quantities.

These objects are attained by a dual band antenna means according to the invention as defined in the appended claims.  
30 In arranging helical coils coaxially and coextending a compact configuration of the antenna means and operability within separated frequency bands are attained. According to simulation and test results it has been confirmed that an antenna means consisting of two helical coils, tuned to frequencies within  
35 two respective non-overlapping frequency bands and arranged concentrically, one inside the other with a small separation will fulfill the electrical demands for efficiency, lobe pattern, and bandwidth, in spite the fact that they couple

capacitively and inductively to each other. This way of arranging the coils does not require any essential enlargement of a housing compared to that which encloses a single helical radiating element of an antenna means tuned to the lower frequency band only. In fact, some preferred configurations facilitate the arrangement of a relatively high inner coil serving an upper band approximately twice as high as the lower band. A higher inner coil tends to give a better lobe pattern for its frequency band.

The term feeding portion used in the description and claims should be interpreted as a conductive body at which a coil is fed with RF energy. It may be a part of a thread of a coil, a part of the radio communication device, and/or a body arranged between a coil and the radio communication device.

Although some geometrical configurations of the helical elements disclosure therein may visually appear similar to that of the present invention, EP-A1 0 593 185 is directed towards solving a problem different to the problem herein and provides a solution that operates differently to the present invention from an electrical and an electromagnetic point of view. The inventive antenna means is not directed towards widening an operating band of a helical element, but to enable two (or more) helical elements that operate in close proximity to provide operability within separated frequency bands. In fact, the relative bandwidth of at least one frequency band of the present invention tends generally to be smaller than that of the corresponding helical element alone.

The invention is applicable in a number of versions. The explanation and the table below indicate some possible and some preferred combinations:

1) All coils wound in same direction; 2) At least one coil wound in other directions; 3) All coils coupled to a single feed portion; 4) At least two feed portions feeding different coils; 5) No coil being mainly fed inductively/capacitively by



another coil; 6) At least one coil being mainly fed through inductive/capacitive interaction with another coil.

	3)	4)	5)	6)
5	1) preferred	possible	preferred	possible
	2) possible	possible	possible	possible
	3) -	not available	preferred	possible
	4) not available	-	possible	not available

10 In the embodiment of two coils intercoupled at one end, wound in the same direction, and arranged one inside the other, the antenna means has been shown to exhibit specifically good results with regard to efficiency, lobe pattern, and bandwidths as well as to utilization of available space. In that mode the  
15 coils interact constructively. Different winding directions seem to give less bandwidth in at least one band. Feeding one coil inductively/capacitively from another coil seems to give lower efficiency in at least one band.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows in an exploded view of a first embodiment of an antenna means according to the invention including a metallic fitting, first and second helically configured elements, a non-  
25 conductive core, and a non-conductive housing.

Fig. 2 shows the antenna means of fig. 1 assembled but without the housing.

Fig. 3 shows in an exploded view of a second embodiment of an antenna means according to the invention including first and  
30 second helically configured elements with feed portions, a non-conductive core, and a non-conductive housing with a fastening groove.

Fig. 4 shows the antenna means of fig. 3 assembled but without the housing.

35 Fig. 5 shows in a partly cut-away view another core which is a possible alternative to the cores of figs. 1 - 4.

Fig. 6 shows in a diagram the standing wave ratio as a function of the frequency for the antenna means of figs. 1 and 2,

wherein the required bandwidths are indicated by horizontal lines for two separated frequency ranges.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

5 With reference to figs. 1 and 2, a first embodiment of the dual band antenna means according to the invention includes a first coil 1 (helically configured element) and a second coil 2 having a first and a second resonance frequency, respectively,  
10 a substantially cylindrical, non-conductive core 3 provided with an external first groove 4 and an external second groove 5 for the first and the second coils, respectively, a non-conductive housing 6 for housing and protecting the coils and the core, and a conductive fitting 7 (feed portion), to which  
15 the coils are coupled and the core fastened, and which connects the antenna means to receiver and transmitter circuits of, e.g., a hand portable cellular telephone (not shown). The first coil 1 has a diameter larger than that of the second coil 2. The first and second coils are wound in the same direction and  
20 the coils and their corresponding grooves in the core are adapted in size and configuration in order for the second coil 2 to fit coaxially inside the first coil 1. The coils are not in galvanic contact with each other except through the metallic fitting 7, to which they are soldered, pressed, glued, or  
25 welded.

Fig. 6 indicates, in a diagram having the frequency along the horizontal axis starting at 500 MHz at the axis intersection increasing by 200 MHz for every marked point on that axis and  
30 having the VSWR along the vertical axis starting at 1.0 at the axis intersection increasing by 1.0 for every marked point on that axis, a VSWR characteristics curve in two parts 61 and 63 for the antenna means of figs. 1 and 2 when the first coil 1 and the second coil 2 have winding diameters of 4.8 mm and 7  
35 mm, pitches of 3.5 mm and 6 mm, respectively, coil axial lengths (height) < 24 mm, and equal wire thicknesses of 0.5 mm. The antenna means thereby exhibits operability within two separated frequency bands at approximately 900 MHz and 1800 MHz

- 1900 MHz shown by horizontal lines 62 and 64, respectively. The antenna means exhibiting these characteristics was mounted on a chassis of a typical hand-portable cellular telephone.

5 With reference to figs. 3 and 4 a second embodiment of the dual band antenna means according to the invention includes a first coil 21 and a second coil 22 having at one end, respectively, for coupling the antenna means to receiver and transmitter circuits of, e.g., a hand portable cellular telephone (not  
10 shown), feed portions extending parallel to the axis of the coils and having a first and a second resonance frequency, respectively, a substantially cylindrical, non-conductive core 23 provided with an external first groove 24 and an external second groove 25 for the first and the second coil,  
15 respectively, and a non-conductive housing 26 provided with a third groove 27 intended for fastening the antenna means to a chassis of the cellular telephone. The first coil 21 has a diameter larger than that of the second coil 22. The first and second coils are wound in opposite directions and the coils and  
20 their corresponding grooves in the core are adapted in size and configuration in order for the second coil 22 to fit coaxially inside the first coil 21. The coils are not in galvanic contact with each other except, possibly, through the transceiver circuits. The antenna means according to figs. 3 and 4 exhibit  
25 two possible and independent electrical features different from those of figs. 1 and 2, namely that its coils are wound in opposite directions and that its coils may easily be connected separately to different transceiver circuits.

30 As an alternative, in the embodiments of figs. 1-4, it is possible to essentially feed one of the coils 1, 2 inductively/capacitively from the other coil 2, 1, which is fed mainly via the feeding portion.

35 Fig. 5 shows, with a partial section 46, an alternative configuration of the core which is to carry the coils. The depicted core 43 is hollow and substantially circular cylindrical. It is provided with an external groove 44 and an

internal groove 45 intended for receiving the first and second coils (not shown), respectively.

Although the invention is described by means of the above  
5 examples, naturally, many variations are possible within the  
scope of the invention. Such variations are, for example,  
variation of the helical diameter of one or both coils along  
the length thereof, using more than two helical coils in order  
to attain operability within more than two separated frequency  
10 bands and/or to increase the bandwidth of at least one of the  
separated non-overlapping frequency bands. It would also be  
possible to use additional elements in this antenna means for  
exclusively transmitting or receiving within a frequency band  
covered by the antenna. Moreover, the coupling of the coils to  
15 the feeding portion(s) could be achieved by capacitor means  
coupling RF energy.

## CLAIMS

1. An antenna means comprising:

- at least one feed portion coupled to circuitry of a hand-portable radio communication device,
- a helically configured conductive first element having a first axial length, first and second ends, as well as a first pitch and a first diameter,
- a conductive second element having a second axial length and third and fourth ends,
- said first and second elements being arranged substantially coaxially and, at least partially, axially coextending with each other, in order for said antenna means to perform transmission and reception within each one of a first frequency band and a second frequency band, which are separated from each other, and whose center frequencies have the ratio of approximately 1:2

characterized by

- said second and fourth ends being free ends,
- said second element being helically configured and having a second pitch and a second diameter.

2. An antenna device according to claim 1, characterized by

- said first element essentially effecting transmission and reception within said first frequency band,
- said second element essentially effecting transmission and reception within said second frequency band separated from said first frequency band.

3. An antenna device according to claim 1 or 2, characterized by

- said first end and said third end being inter-coupled at said at least one feed portion.

4. An antenna device according to any one of claims 1-3,  
c h a r a c t e r i z e d    b y
- said second diameter being smaller than said first dia-  
meter,
  - 5    - said second element being arranged inside said first  
element.
5. An antenna device according to claim 1, or 4,    c h a r a c -  
t e r i z e d    b y
- 10    - one of the first and second elements being fed mainly  
through inductive/capacitive coupling to the other one,  
which in turn is coupled to said at least one feed portion.
6. An antenna device according to any one of claims 1-4,  
15    c h a r a c t e r i z e d    b y
- said second diameter being substantially equal to said  
first diameter,
  - said second pitch being substantially equal to said first  
pitch.
- 20    7. An antenna device according to any one of claims 1-6,  
c h a r a c t e r i z e d    b y
- reception and transmission of RF signals according to a  
first telecommunication standard being performed within
  - 25    said first frequency band,
  - reception and transmission of radio signals according to a  
second telecommunication standard, other than said first  
telecommunication standard, being performed within said  
second frequency band.
- 30    8. An antenna device according to any one of claims 1-4,  
c h a r a c t e r i z e d    b y
- said first and second elements being wound in the same  
direction.

35

9. An antenna device according to any one of claims 1-3,  
c h a r a c t e r i z e d   b y  
- said first and second elements being wound in opposite  
directions.

5

10. An antenna device according to claim 1,   c h a r a c t e -  
r i z e d   b y

- at least one further helically configured conductive  
element having a resonance peak at a frequency different  
from both said first and second frequencies.

10

1 / 1

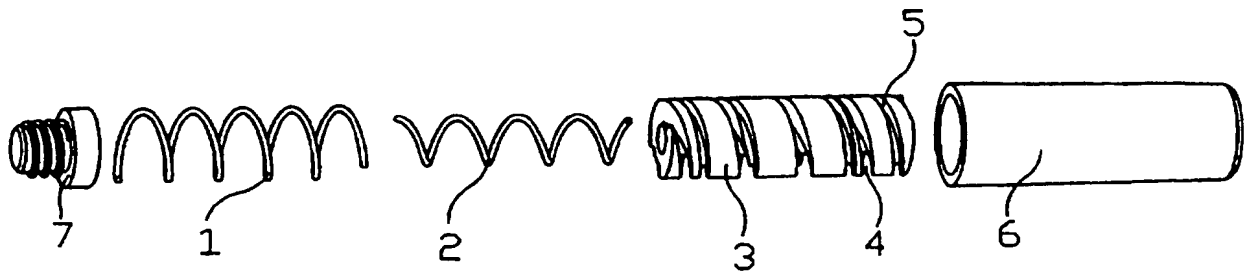


Fig. 1

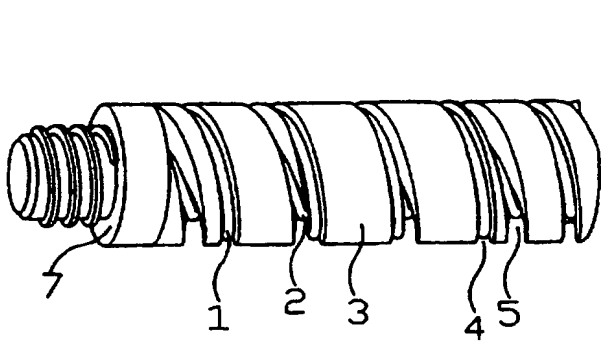


Fig. 2

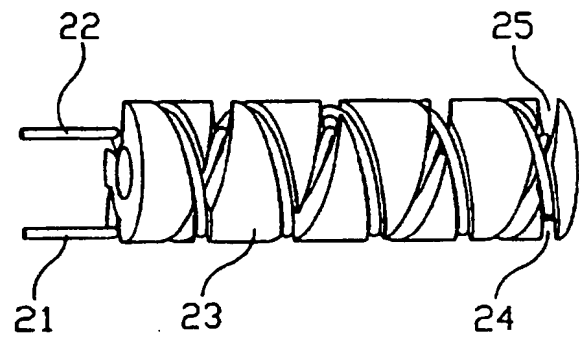


Fig. 4

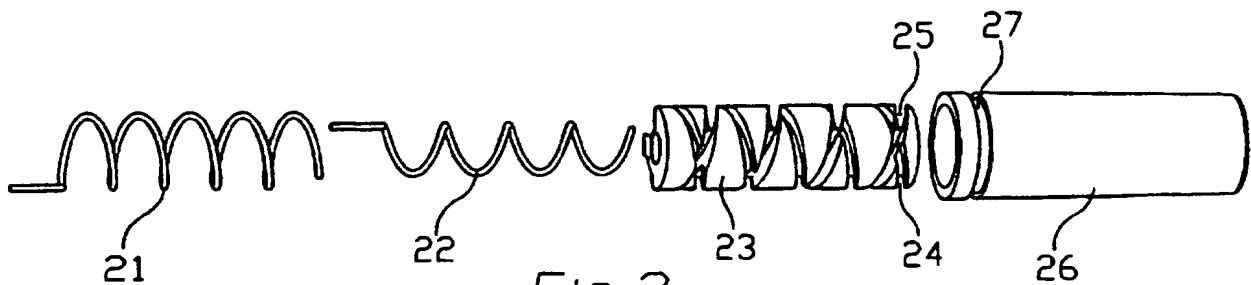


Fig. 3

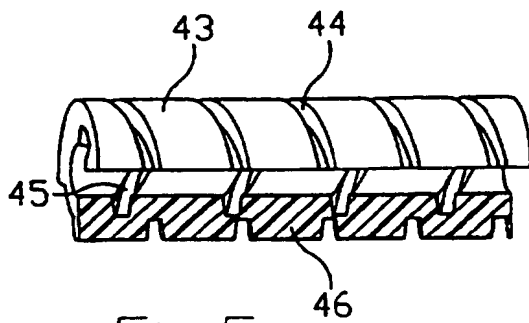


Fig. 5

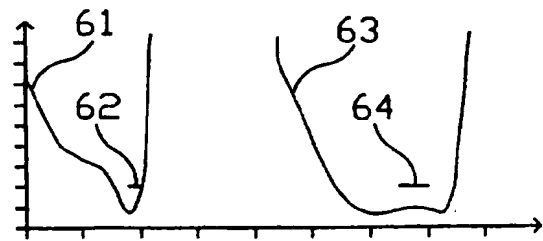


Fig. 6



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/01483

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01Q 1/36

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2206243 A (PANORAMA ANTENNAS LTD.), 29 December 1988 (29.12.88), cited in the application --	1-10
A	US 4772895 A (O.M.GARAY ET AL), 20 Sept 1988 (20.09.88), cited in the application --	1-10
A	EP 0593185 A1 (NOKIA MOBILE PHONES LTD.), 20 April 1994 (20.04.94) --	1-10
A	WO 9414207 A1 (SIEMENS AKTIENGESELLSCHAFT), 23 June 1994 (23.06.94), figure 2, abstract --	1-10

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/01483

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0528775 A1 (ERICSSON-GE MOBILE COMMUNICATIONS INC.), 24 February 1993 (24.02.93), see figure --	1-10
A	US 4442438 A (SIWIAK ET AL), 10 April 1994 (10.04.94), cited in the application --	1-10
A	US 4309707 A (J.R.JAMES ET AL), 5 January 1982 (05.01.82), cited in the application -- -----	1-10

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.  
**PCT/SE 96/01483**

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB-A-	2206243	29/12/88	NONE		
US-A-	4772895	20/09/88	NONE		
EP-A1-	0593185	20/04/94	GB-A, B-	2271670	20/04/94
			IL-D-	107272	00/00/00
			JP-A-	6204726	22/07/94
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			SE-B, C-	468917	05/04/93
			SE-A-	9102379	17/02/93
			US-A-	5592184	07/01/97
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